

GUEST EDITORIAL

Is Your Research Moral?



The author of this invited editorial is chairman of physics at Stanford. He has three degrees from Toronto, and before going to Stanford he worked at Research Enterprises, Columbia University and Bell Telephone Laboratories. His research has been in rf, microwave and optical spectroscopy, solid-state physics and quantum electronics.

Nowadays science and scientists are being attacked from all directions. On the one side there are those in Congress, the military and the general public who say that if science were doing what is expected, it would have won the war in Vietnam and produced horrible new weapons to terrify all possible enemies. On the other side many students and intellectuals, even including some scientists, say that if scientists were doing their job properly, they should have produced an end to poverty, racism, air pollution, overpopulation and war. Strangely, both opposed groups of critics argue that since science has not performed according to their specifications, either scientists are misdirecting their efforts or perhaps science is irrelevant and has little to contribute to the solution of important human problems. Both groups equally fail to understand the real nature of scientific discovery and the ways in which scientific knowledge eventually makes possible the goals people desire.

A fuller understanding of nature is esthetically pleasing and deeply satisfying, but its social significance comes because it is also useful. It makes us prophets so that we and our successors can predict what can happen and can

even tell something of the consequences that will follow if we make something occur. Part of the attraction of physics is that simple laws and concepts have extremely far-reaching consequences and apply in a very wide range of situations. For just this reason the ultimate applications of physical discoveries are almost never apparent at the beginning. We all know something of the long history extending from the nuclear atom and the mass-energy equivalence to atomic power. We who know such history should recall it and tell it to those who question the nature and utility of science.

Let me give two examples from relatively recent technological history. The first I know personally, for when Charles Townes and I were trying in 1957 to see whether the maser principle could yield a generator of coherent radiation in or near the range of visible wavelengths, we gave almost no thought to applications. I had never heard of a detached retina, and yet one of the earliest applications of lasers was for eye surgery to prevent retinal detachment. Although lasers are still quite primitive and many of the more obvious applications remain

impractical, they have been applied to a wide range of needs, most of which could hardly have been foreseen except by a person who specialized in the particular area of application. But if we had tried to attack these needs head on, as might have been done by a specialist in eye surgery, we would never have been thinking about stimulated emission from atomic systems.

Considerably more important consequences have come from Felix Bloch's discovery of the concept of energy bands in solids and their influence on conduction of electricity. In the 20 years after Bloch's 1928 thesis, the band ideas guided the whole development of solid-state physics. And yet, as late as 1953, 25 years after the discovery, one could have said truthfully that these ideas had not led to greatly improved metals nor to any other important practical consequences. But a year or so later, there began serious applications of the transistor, a device that really could not have been invented without the conceptual framework of the band theory. Now, the impact of the use of transistors and other semiconductor devices on human life is already enormous. To take a few examples, there are cardiac pacemakers

and the ubiquitous transistor radio, which is playing such an important role in unifying some developing countries. Without semiconductor devices the entire space program would be nearly impossible. It is hard to conceive of either the human aspects of space flight (such as environmental and weather-observation satellites), the scientific aspects (such as astrophysical observatories and moon landing probes) or the military aspects without large-scale and lightweight semiconductor computers. In industry, it seems quite possible that semiconductor logic will eliminate a large part of the routine drudgery that seemed for a while to be an inescapable consequence of mass production. None of this could possibly have been foreseen at the time of the original scientific discovery. Yet from all our experience we should have faith that scientific ideas do have consequences, important consequences that greatly increase the range of decisions that man can make. It is the nature of man to make choices and to master his environment. With science and its consequences we have the tools to make decisions, good or bad. If we sacrifice scientific research for immediate social gains, we might have a

short-range benefit, but we are surely mortgaging our future.

After applications of science become apparent, the people and their representatives must decide whether the applications are good or bad. Here scientists must play a part by sharing knowledge of the possible courses and their likely consequences. If the facts are known, we can be optimistic that the people will more often choose courses to their own benefit than the reverse. Every thinking scientist must have faced this question and concluded that, broadly, scientific discoveries do eventually open up badly needed alternatives from which more good than evil will be extracted.

Whatever the grounds for such faith, whether from a religious conviction or from a knowledge of scientific and technological history, we must put these concerns aside when we confront the mysteries of the universe. In the light of this belief that good things do eventually come from new knowledge, I am convinced that good scientific research is a highly moral activity. The only kind that is not moral is that which can be characterized by a phrase of Wolfgang Pauli's: "It isn't even wrong."

—Arthur L. Schawlow